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(54) LOOP ANTENNA FOR CIRCULARLY POLARIZED WAVE

(57) A circularly polarized wave loop antenna can operate in a wide frequency range as well as it can be simply constructed. A radiating power fed to a feeding point (5) via a coaxial line (4) and a feeder conductor (7) is transmitted through an I-shape conductor (2) to a C-type loop element (1). By the action of a cutoff part (6) formed on the C-type loop element, the C-type loop element radiates a circularly polarized wave. An appropriate angle is between 35° and 45° that the I-shape conductor and the cutoff part should form.

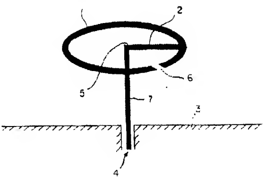

FIG.1

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Description

TECHNICAL FIELD

The present invention relates generally to a circularly polarized wave loop antenna, particularly to a loop antenna that is suitable for use in a terminal device for a communication system of a circularly-polarized wave mode.

BACKGROUND ART

Of the circularly polarized wave loop antennas, one having a thin and low construction is suitable as an antenna for being mounted on mobile facilities such as automobiles and aircraft, since projections made by the antenna being mounted cannot apparently be seen, and there have been various proposals for the circularly polarized antenna. One example is a "loop antenna having passive element, B-104" which was announced by Mr. Hisamatsu Nakano and three others, in the spring national conference of the Japan Electronic Information Communication Institute of 1994 and recorded in page 2-104. The abovementioned circularly polarized wave loop antenna is shown in Fig. 5 through Fig. 7, Fig. 6 illustrates a C1-type circularly polarized wave loop antenna as a first example, and Fig 7 illustrates a C2-type circularly polarized wave loop antenna as a second example.

Fig. 5 is a front elevation view of the circularly polarized wave antenna, and Fig. 6 is a top view of the C1-type circularly polarized wave loop antenna.

The C1-type circularly polarized wave loop antenna has a coaxial feeder loop element 100 placed in parallel to a ground plane 105, and a passive loop element 101 having a larger diameter than the coaxial feeder loop element 100, which is placed above and in parallel to the coaxial feeder loop element 100 with maintaining a concentric configuration thereto. The space between the ground plane 105 and the coaxial feeder loop element 100 is specified as H_1, and the space between the ground plane 105 and the passive element 101 is specified as Hp.

In the circularly polarized loop antenna thus constructed, the coaxial feeder loop element 100 is fed such that one end of an I-shape conductor 104 is, as shown in Fig. 6, connected to the coaxial feeder loop element 100 and the other end of the I-shape conductor is connected to a feeder conductor 106. The feeder conductor 106 is connected to a central conductor of a coaxial line 102, as shown in Fig. 5.

The passive loop element 101 is provided with a cutoff part 103; an angle formed by the cutoff part 103 and the I-shape conductor 104, and a length of the cutoff part 103 are specified as ϕ_p, and Δg, respectively.

In this case, provided that the angle ϕ_p is specified to be close to +45° or -135°, a left-handed circularly polarized wave will be radiated by the action of the cutoff part 103; provided that the angle ϕ_p is specified to be close to -45° or +135° a right-handed circularly polarized wave will be radiated by the action of the cutoff part 103. Thereat, a current of a virtually progressive wave flows in the coaxial feeder loop element 100 and the passive loop element 101. When the circumferential length of the coaxial feeder loop element 100, C1 $=1\lambda$, the circumferential length of the passive loop element 101, C2 $=1.25\lambda$, $H_1=0.0667\lambda$, Hp $=0.0792\lambda$, $\Delta g=0.0104\lambda$, $\phi_p=\pm42°$ or 139° are given, wherein λ is the natural space wavelength, the gain vs. frequency characteristics of the C1-type circularly polarized wave loop antenna is shown as b in Fig. 3, and the circularly polarized wave axial ratio vs. frequency characteristics is shown as b in Fig. 4.

Fig. 7 is a top view of the C2-type circularly polarized wave loop antenna. The C2-type circularly polarized wave loop antenna has the coaxial feeder loop element 100 placed in parallel to the ground plane 105, and the passive loop element 101 having a larger diameter than the coaxial feeder loop element 100, which is placed above and in parallel to the coaxial feeder loop element 100 with maintaining a concentric configuration thereto. The space between the ground plane 105 and the coaxial feeder loop element 100 is specified as H_1, and the space between the ground plane 105 and the passive element 101 is specified as Hp.

In the C2-type circularly polarized loop antenna thus constructed, the coaxial feeder loop element 100 is fed such that one end of the I-shape conductor 104 is, as shown in Fig. 7, connected to the coaxial feeder loop element 100 and the other end of the I-shape conductor is connected to the feeder conductor 106. The feeder conductor 106 is connected to the central conductor of the coaxial line 102, as shown in Fig. 5.

The passive loop element 101 is provided with two cutoff parts 103 located opposite to each other; an angle formed by the cutoff part 103 and the axis of the I-shape conductor 104, and the length of the cutoff part 103 are specified as ϕ_p, and Δg, respectively.

In this case, provided that the angle ϕ_p is specified to be close to +45° and -135°, a left-handed circularly polarized wave will be radiated by the action of the cutoff parts 103; provided that the angle ϕ_p is specified to be close to -45° and +135°, a right-handed circularly polarized wave will be radiated by the action of the cutoff parts 103. Thereat, a current of a virtually progressive wave flows in the coaxial feeder loop element 100 and a standing wave current flows in the passive loop element 101.

When the circumferential length of the coaxial feeder loop element 100, C1 $=1\lambda$, the circumferential length of the passive loop element 101, C2$=1.25\lambda$, $H_1=0.0667\lambda$, Hp $=0.1\lambda$, $\Delta g=0.01042\lambda$, $\phi_p=+23°$, -113° or -23°, + 113° are given, wherein λ is the natural space wavelength, the gain vs. frequency characteristics is shown as c in Fig. 3, and the circularly polarized wave axial ratio vs. frequency characteristics is shown as c in Fig. 4.

However, in the conventional circularly polarized

wave loop antenna as shown in Fig. 3 and Fig. 4, the frequency bandwidth wherein a specific gain is produced is narrow and the frequency bandwidth wherein the circularly polarized wave axial ratio of 3.0dB or less is given is so narrow as about 1.2%, which is a problem.

Further, the conventional one needs two loop elements of the coaxial feeder loop and the passive loop, which makes the construction complicated, giving another problem.

It is therefore an object of the present invention to provide a circularly polarized wave loop antenna that can widen the frequency bandwidth wherein a specific gain and a specific circularly polarized wave axial ratio vs. frequency characteristics are attained, and it is a further object to provide a simply constructed circularly polarized wave loop antenna.

DISCLOSURE OF THE INVENTION

With the foregoing object in view, the circularly polarized wave loop antenna according to the present invention comprises a C-type loop element having a cutoff part and an I-shape conductor of which one end is connected to the C-type loop element and the other end is served as a feeding point, and which extends in the radial direction of the C-type loop element, wherein the C-type loop element is placed face to face with a ground plane with a specific space.

In the foregoing circularly polarized wave loop antenna, the angle formed by the cutoff part provided on the C-type loop element and the I-shape conductor is specified to be about $\pm 35° \sim \pm 45°$ or about $\pm 135° \sim \pm 145°$; the circumferential length of the C-type loop element is specified to be about $1.0\lambda \sim 1.5\lambda$, the space between the C-type loop element and the ground plane to be about $0.05\lambda \sim 0.26\lambda$, the length of the I-shape conductor to be about $0\lambda \sim 0.47\lambda$, wherein the natural space wavelength is given as λ.

According to the present invention, since a circularly polarized wave loop antenna can be made by one loop element, the construction will be simpler and the circularly polarized loop antenna can also be made in a small and low construction; and therefore, it will be suitable for a BS or GPS antenna mounted on mobile facilities.

Since the circularly polarized wave loop antenna can be fed through a coaxial feeder, the feeder loss can be reduced, making the loop antenna hard to be influenced by conditions surrounding the feeder.

Further, since the circularly polarized wave loop antenna according to the present invention has a broad frequency characteristics against the circularly polarized wave axial ratio and a broad gain vs. frequency characteristics having a high gain, it can be used as a shared antenna in a communication system which transmits a plurality of circularly polarized wave modes with different frequencies. Since it has a broad antenna input impedance vs. frequency characteristics, the production process can be simpler, thereby reducing the production cost.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a perspective view showing a construction of one embodiment of the circularly polarized wave loop antenna according to the present invention, Fig. 2 is a front elevation and top view showing a construction of one embodiment of the circularly polarized wave loop antenna according to the present invention, Fig. 3 is a chart showing a gain vs. frequency characteristics of the circularly polarized wave loop antenna according to the present invention and the conventional construction, Fig. 4 is a chart showing a circularly polarized wave axial ratio vs. frequency characteristics of the circularly polarized wave loop antenna according to the present invention and the conventional construction, Fig. 5 is a front elevation view showing one example of a construction of the conventional circularly polarized wave loop antenna, Fig. 6 is a top view showing one example of a construction of the conventional circularly polarized wave loop antenna, and Fig. 7 is a top view showing another example of a construction of the conventional circularly polarized wave loop antenna.

BEST MODE FOR CARRYING OUT THE INVENTION

Fig. 1 is a perspective view showing a construction of one embodiment of the circularly polarized wave loop antenna according to the present invention. In this figure, 1 is a C-type loop element with a cutoff part 6 formed, 2 is an I-shape conductor of which one end is connected to the C-type loop element 1 and the other end is served as a feeding point 5, 3 is a ground plane in parallel to the C-type loop element 1, 4 is a coaxial line for transmitting a power fed to the C-type loop element, and 7 is a feeder conductor of which one end is connected to the feeding point 5 and the other end is connected to a central conductor of the coaxial line 4.

The top view of the circularly polarized wave loop antenna is shown in Fig. 2 (a), and the front elevation view is shown in Fig. 2 (b).

As shown in Fig. 2, the front end of the feeder conductor 7 is connected to the feeding point 5 of the other end of the I-shape conductor 2, whereby the C-type loop element 1 is fed through the coaxial line 4. The other end of the feeder conductor 7 is connected to the central conductor of the coaxial line 4.

When the C-type loop element 1 is thus fed, it radiates a circularly polarized wave by the action of the cutoff part 6.

The space between the ground plane 3 and the C-type loop element 1 is herein specified as h, the angle formed by the axis of the I-shape conductor 2 and the cutoff part 6 as ϕ_a, the length of the cutoff part 6 as Δg, the length of the I-shape conductor as l, and the circumferential length of the C-type loop element 1 as c, although not illustrated.

Next, assuming that the frequency is 11.85 [GHz],

the natural space wavelength is λ, and $c=1.31\lambda$, $h=0.15\lambda$, $\phi_a=320°$, $l=0.208\lambda$, $\Delta g=0.018\lambda$ are given, the gain vs. frequency characteristics and the circularly polarized wave axial ratio vs. frequency characteristics will be shown in Fig. 3, and Fig. 4, respectively.

The gain characteristics of the circularly polarized wave loop antenna according to the present invention is shown as a in Fig. 3, indicating a high gain of about 8.6[dBi] over a broad frequency range of 8%. The axial ratio characteristics of the circularly polarized wave loop antenna according to the present invention is shown as a in Fig. 4, indicating a broad frequency range of about 6.1% wherein the circularly polarized wave axial ratio of 3.0dB or less is attained.

Thus, the circularly polarized loop antenna according to the present invention can broaden the frequency range in which the circularly polarized wave axial ratio of 3.0dB or less is attained about five times compared to the conventional one, and can make the gain high over a wide frequency range as shown in Fig. 3; and therefore, one piece of the circularly polarized wave loop antenna according to the present invention can replace antennas in a communication system which transmits a plurality of circularly polarized wave modes with different frequencies in a frequency range higher than the L-band.

Particularly, since the circularly polarized wave loop antenna according to the present invention can be made small and low, it is suitable for being applied as a GPS or BS antenna mounted on mobile facilities.

The space h between the ground plane 3 and the C-type loop element 1 can be set in the range of about 0.05λ to 0.26λ, the angle ϕ_a formed by the axis of the I-shape conductor 2 and the cutoff part 6 can be set in the range of about 315° ~ 325°, the length Δg of the cutoff part 6 can be set in the range of about 0.01λ~ 0.02λ, the length l of the I-shape conductor can be set in the range of about 0λ ~ 0.47λ, and the circumferential length c of the C-type loop element 1 can be set in the range of about 1.0λ~ 1.5λ.

In the foregoing description, the angle ϕ_a was specified in the range of about 315° ~ 325°; however, forming the cutoff part 6 at the position opposite to the above angle, about 135° ~ 145°, will also produce a circularly polarized wave loop antenna having the characteristics described above. And in order to make a circularly polarized wave loop antenna of an inversely rotating mode, the angle ϕ_a formed by the cutoff part 6 provided on the C-type loop element 1 and the I-shape part 2 is only needed to be about 35° ~ 45° (215° ~ 225°). That is, in the circularly polarized wave loop antenna according to the present invention, the angle ϕ_a is sufficient to be set to ±35° ~ ±45°, or ±135° ~ ±145°.

Since the circularly polarized wave loop antenna according to the present invention has a broad antenna input impedance vs. frequency characteristics which is at least 1.5 times wider than the conventional one, dimensional tolerances on a production line and tolerances on characteristic dispersions of materials in use can be set wider. Therefore, the production process can be simpler, leading to lowering the production cost.

Being fed through the coaxial line 4, the circularly polarized wave loop antenna according to the present invention as in Fig. 1 and Fig. 2 can reduce the feeding loss, and it can be hard to be influenced by the surrounding conditions of the coaxial line 4, thereby maintaining the intrinsic property of the circularly polarized wave loop antenna.

The circularly polarized wave loop antenna can be made such that the C-type loop element 1 is formed on a dielectric substrate by microstrip lines; however, it can also be made by replacing the dielectric material with a foamed material that hardly exerts a dielectric function.

Further, a plurality of small holes are bored on a cylindrical cavity or a straight waveguide along the longitudinal direction and the feeder conductors of the circularly polarized wave loop antenna according to the present invention are inserted into each of the holes, whereby a plurality of the circularly polarized wave loop antennas can be fed. An array antenna can be formed by this construction, which produce a higher gain.

Furthermore, a high gain flat array antenna can be formed by providing multiples of the circularly polarized wave loop antennas according to the present invention on a radial waveguide.

INDUSTRIAL APPLICABILITY

As described above, since the circularly polarized wave loop antenna according to the present invention can be made by one loop element, the construction will be simpler and the circularly polarized loop antenna can also be made small and low; and therefore, it will be suitable for a BS or GPS antenna mounted on mobile facilities.

Since the circularly polarized wave loop antenna can be fed through a coaxial feeder, the feeder loss can be reduced, which will make the loop antenna hard to be influenced by conditions surrounding the feeder, thereby maintaining the intrinsic property of the loop antenna.

Further, since the circularly polarized wave loop antenna according to the present invention has a broad frequency characteristics against the circularly polarized wave axial ratio and a broad gain vs. frequency characteristics having a high gain, it can be used as a shared antenna in a communication system which transmits a plurality of circularly polarized wave modes with different frequencies. Since it has a broad antenna input impedance vs. frequency characteristics, the production process can be simpler, thereby reducing the production cost.

Claims

1. A circularly polarized wave loop antenna comprising:

a C-type loop element having a cutoff part; and an I-shape conductor of which one end is connected to the C-type loop element and another end is served as a feeding point, and which extends in a radial direction of the loop element, wherein the C-type loop element is arranged face to face with a ground plane with a given space.

2. A circularly polarized wave loop antenna as set forth in claim 1, wherein the angle formed by the cutoff part provided on the C-type loop element and the I-shape conductor is about $\pm$ 35° ~ $\pm$ 45° or about $\pm$ 135° ~ $\pm$ 145°.

3. A circularly polarized wave loop antenna as set forth in claim 1 or 2, wherein the circumferential length of the C-type loop element is about 1.0λ ~ 1.5λ, where λ is a natural space wavelength.

4. A circularly polarized wave loop antenna as set forth in any one of claim 1 or 3, wherein a space between the C-type loop element and the ground plane is about 0.05λ ~ 0.26λ, where λ is a natural space wavelength.

5. A circularly polarized wave loop antenna as set forth in any one of claim 1 or 4, wherein the length of the I-shape conductor is about 0λ ~ 0.47λ, where λ is a natural space wavelength.

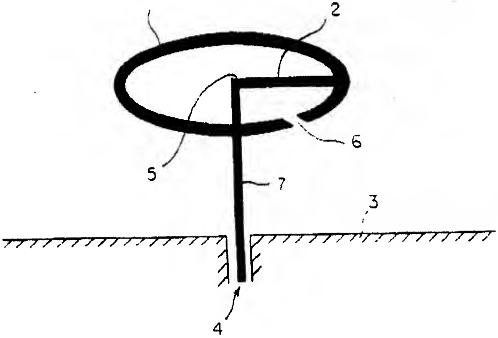


FIG.1

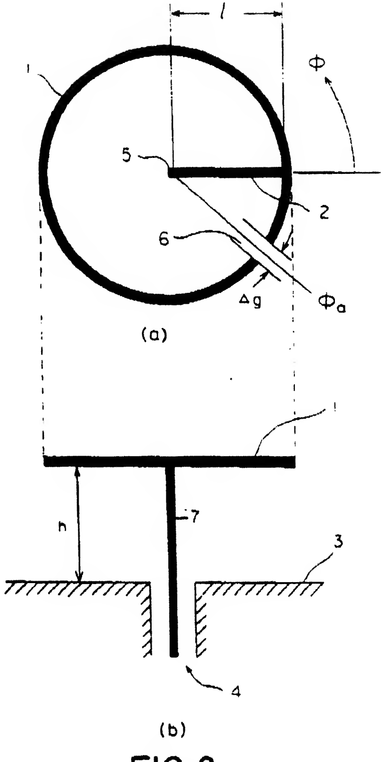


FIG.2

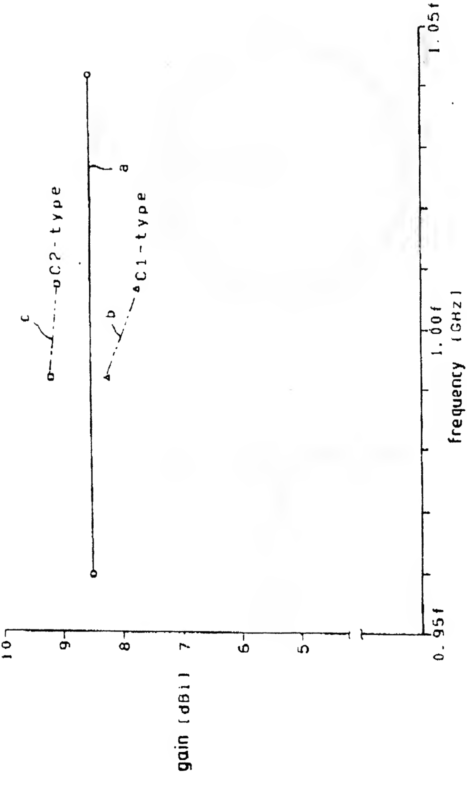

gain [dBi]
10
9
8
7
6
5
0.95f
1.00f
1.05f
frequency [GHz]
C2-type
C1-type
a
b
c

FIG.3

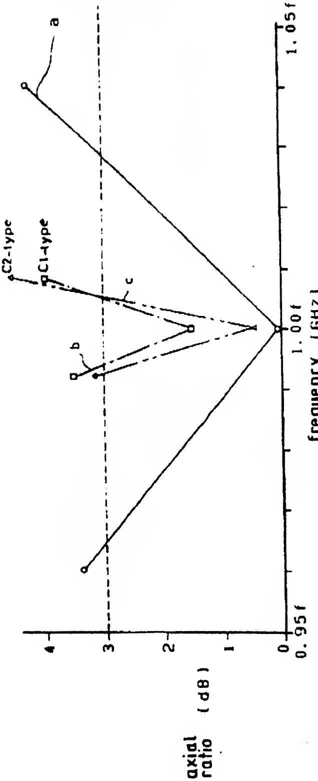

a
C2-type
C1-type
c
b
0
1
2
3
4
axial ratio (dB)
0.95f
1.00f
1.05f
frequency (GHz)

FIG.4

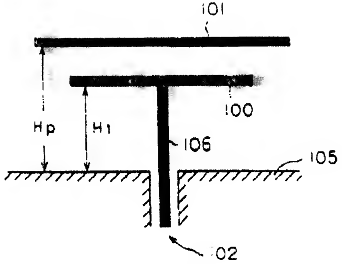
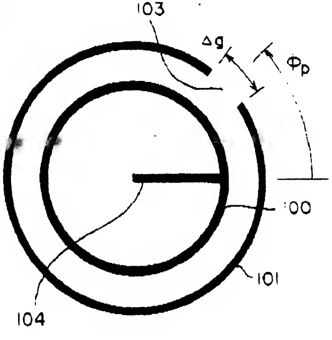
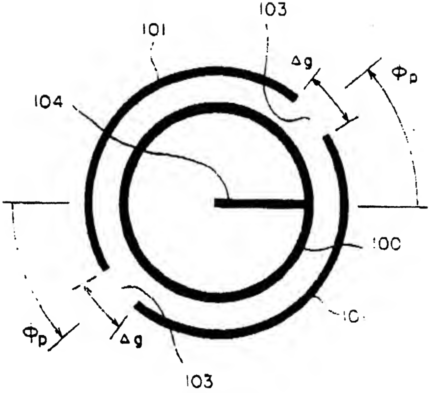


FIG.5



CI-TYPE

FIG.6



C2-TYPE

FIG. 7

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP96/00071

A. CLASSIFICATION OF SUBJECT MATTER

Int. Cl6 H01Q7/00

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

Int. Cl6 H01Q7/00

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Jitsuyo Shinan Koho	1926 - 1995
Kokai Jitsuyo Shinan Koho	1971 - 1995
Toroku Jitsuyo Shinan Koho	1994 - 1995

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	JP, 2-214304, A (Hirose Electric Co., Ltd.), August 27, 1990 (27. 08. 90), Fig. 1 (Family: none)	1 - 5
X	JP, 4-80114, U (Hirose Electric Co., Ltd.), July 13, 1992 (13. 07. 92), Fig. 1 (Family: none)	1 - 5
P,X	JP, 7-249921, A (Nippon Denki Kosaku K.K.), September 26, 1995 (26. 09. 95), Fig. 1 (Family: none)	1 - 5

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
March 29, 1996 (29. 03. 96)	April 23, 1996 (23. 04. 96)

Name and mailing address of the ISA/	Authorized officer
Japanese Patent Office	
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